WEED CONTROL IN ROADSIDE PLANTINGS

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by

F. O. LANPHEAR
AND
R. L. SPANGLER

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

WEED CONTROL IN ROADSIDE PLANTINGS

To: G. A. Leonards, Director
Joint Highway Research Project

November 4, 1966

File: 9-5-3

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-48c

Attached is the first formal Progress Report on the HPR Project entitled "Roadside Development" since it was expanded to this title from "Chemical Weed Control" This report is entitled "Weed Control in Roadside Plantings" by F. O. Lanphear and R. L. Spangler. This report is on Part II of the research on "Selection, Establishment and Maintenance of Woody Ornamental Plants for Highway Plantings."

The report presents the activity and findings to date on that portion of Part II dealing with weed control in plantings of ornamental plants along highways.

The report will also be submitted to the Highway Commission and to the Bureau of Public Roads for their review and comment.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Secretary

HLM:jgs

Attachment

Copy:

F. L. Ashbaucher
J. R. Cooper
J. W. Delleur
W. L. Dolch
W. H. Goetz
W. L. Grecco
G. K. Hallock
F. S. Hill
J. F. McLaughlin
F. B. Mendenhall
R. D. Miles
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M. B. Scott
F. W. Stubbs
K. B. Woods
E. J. Yoder

Progress Report

WEED CONTROL

IN ROADSIDE PLANTINGS

By

F. O. Lanphear
Associate Professor of Horticulture

Ronald L. Spangler
Graduate Assistant

Joint Highway Research Project

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General Introduction

The problem of weed control in roadside plantings is of major concern in any highway landscaping program. The high cost of continual maintenance around these plantings is primarily related to the problem of weed control. Presently the practice is to mulch during the planting operation, frequently with materials such as corncobs or sawdust that very often accentuates an already acute nutritional deficiency, and then to use manual labor to remove the weeds the mulch does not control in subsequent years. The presence of weeds in these plantings is not only unattractive but they compete with the woody ornamental plants for nutrients and moisture that are not always very plentiful under highway conditions.

This weed control was considered most important to solve initially in the overall problem of selection, establishment, and maintenance of roadside plantings, since it affects both selection and establishment and probably is the most costly phase of the landscape program over a period of years.

The primary objectives in this phase of the research program were to 1) investigate methods of chemical weed control specifically designed for roadside plantings; 2) devise new techniques to facilitate the application of these chemical herbicides and 3) provide protective measures for woody ornamental plants that may be injured by the herbicides. These three objectives are considered separately under the following headings:

Herbicide Combinations

Incorporation of Herbicides in Mulches

The Use of Activated Carbon for Localized Herbicide Protection

HERBICIDE COMBINATIONS

Introduction

Weed control in highway plantings can be achieved either mechanically or chemically. Because of high labor cost and the season when weeds must be removed, mechanical or hand labor methods of controlling weeds is prohibitive. In the past few years there has been an increased use of chemical to control weeds. Herbicides have been used to reduce labor costs and to provide weed control when the weeds are germinating and growing.

An ideal herbicide could be applied in the fall or spring and should control a broad spectrum of weeds for long periods of time. In addition, an ideal herbicide should not be toxic to the crop nor should toxicity build up with repeated use. Herbicides today are able to perform only a part of the requirements necessary for good weed control. For example, some herbicides do control particular weeds for long periods of time, however, they are either toxic to the crop or do not control a broad spectrum of weeds.

Because no single herbicide has been developed that can meet all the standards required, new formulations or methods must be developed that will meet all these requirements. One possible method to more efficiently control weeds is to combine individual herbicide components using lower concentrations of each to better meet the requirements for broad spectrum weed control, at the same time reducing injury to the crop. Advocates of herbicide combinations list several possible advantages by the use of herbicide combinations. Some of these advantages are:

1. Control of more kinds of weeds.
2. Improved control of a particular weed.
3. Reduction in crop and soil residues.
4. Reduction in cost.

5. Extended weed control over a longer period of time.

6. More selectivity by synergistic effects.

7. Reduction in crop injury.

The principle of herbicide combinations has been studied in vegetable production. Herbicide combinations are used in the growing of many vegetable crops. However, with woody ornamental plants, little work has been conducted to determine the possible ways in which herbicide combinations may be applied.

The purpose of this study is to explore the possibilities of combining herbicides into combinations that would control a broad spectrum of weeds, remain active in the soil for long periods of time, and to reduce toxicity to the crop. The program of study is to (1) develop methods in which herbicide components can be evaluated as potential components for herbicide combinations; (2) formulate possible combinations that may be effective under different conditions; (3) determine the optimum time to apply herbicides; (4) determine the amount of injury to crops; (5) determine what effect the environment has on the rate of herbicide breakdown in the soil.

Following is a progress report describing the work and results that have been completed. In addition, a discussion of future plans will be included.

Materials and Methods

Determination of minimum effective concentration:

Experiments were conducted using three herbicide components: Simazine, Diphenamid, and Dichlobenil.[1] Nine species of weeds (Table 1) were selected for the preliminary weed control studies. In the first series of experiments each herbicide was applied at six different concentrations (Table 2).

Each treatment was replicated four times and randomized. The weed species were planted in plastic trays 7 x 5 x 1 3/4 inches, containing sterilized loam and no additional organic matter. The weed species were sown in rows, each species containing a certain number of seeds per row. The seeds were then lightly covered with sand to assure uniform penetration of the spray and watered lightly. The herbicide was applied as a spray with a controlled rate of application. The flats were placed in the greenhouse. After approximately one month the total number of weeds growing were counted.

After the minimum concentration required to control individual species was determined, the weed species Yellow Foxtail, Velvetleaf and Smartweed were allowed to grow for a period of three months. The remaining seven species were discarded. After three months these weeds were then removed from the flats (the soil being disturbed as little as possible) and the same species were resown as in the initial experiment. However, at this time no additional herbicide was applied. These flats were treated in the same manner as previously described. At the end of one month the total number of weeds growing was counted. Thus the effect of an initial minimum concentration of herbicide required to control weed growth was calculated as well as a residual effect of the same concentrations.

<u>Field Plot Experiments</u>

After minimum concentrations were determined, fifteen herbicide combinations were formulated and taken to the field to be evaluated.

The fifteen herbicides and combinations (Table 3) were applied on cultivated plots measuring 5 x 7 feet on June 6. The herbicides were applied as wettable sprays using a tractor mounted boom-type sprayer. Immediately

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[1] See appendix.

Table 1. List of weeds used in greenhouse experiments.

Common Name	Scientific Name
Barnyard grass	*Echinochloa crusgalli*
Common chickweed	*Stellaria media*
Crabgrass	*Digitaria sanguinalis*
Jimson weed	*Datura stramonium*
Lambsquarter	*Chenopodium album*
Pigweed	*Amaranthus retroflexus*
Shepherd's purse	*Capsella bursa-pastoris*
Smartweed	*Polygonum sp.*
Velvet leaf	*Abutilon theophrasti*
Yellow foxtail	*Setaria lutescens*

Table 2. Herbicide formulation and rate of application in lbs/A used in preliminary greenhouse study to determine effective concentrations for control of specific weeds.

Simazine 80 WP	Diphenamid 80 WP	Casoron 50 WP
3	6	4
2	5	3
1	4	2
3/4	3	1 1/2
1/2	2	1
1/4	1	1/2

Table 3. Herbicide and combinations applied in field studies (rates expressed in lbs/A).

Treatment Number	Herbicide Treatment
1	Check
2	Simazine (3)
3	Simazine (1)
4	Diphenamid (6)
5	Diphenamid (4)
6	Simazine (½) + diphenamid (2)
7	Simazine (½) + diphenamid (4)
8	Simazine (1) + diphenamid (2)
9	Simazine (1) + diphenamid (4)
10	Dichlobenil (4)
11	Dichlobenil (2)
12	Dichlobenil (1) + diphenamid (2)
13	Dichlobenil (1) + diphenamid (4)
14	Dichlobenil (2) + diphenamid (2)
15	Dichlobenil (2) + diphenamid (4)

following application the field plots were irrigated, primarily to incorporate dichlobenil which is highly volatile.

After the irrigation treatment, the field plots were left undisturbed for one month. Weed counts were then taken. Four, one square foot counts were taken in each replication making a total of 16 square feet sampled per treatment. After the weed counts had been taken the plots were scraped and the weeds removed. The soil was disturbed as little as possible in order not to disturb the herbicide for subsequent weed control. The same procedure was followed for the remaining two weed counts. Irrigation was applied once in June and once in early August.

Results and Discussion

Greenhouse Experiments.

The purpose of applying different concentrations of individual components was to determine the effect of different concentrations of herbicides on particular weed species. It is known that the concentration of herbicides required for weed control varies with the weed species.

Fig. 1 shows the effect of dichlobenil on two species; pigweed, a broadleaf weed and crabgrass, a grass. As shown, dichlobenil will control the broadleaf weed at a lower concentration than required for crabgrass. Dichlobenil is usually considered to be more effective on broadleaf weeds than on grasses. However, at the higher concentration crabgrass can be controlled. It is significant to note that both species was controlled at a concentration less than 4 lbs/Acre actual. Dichlobenil has the disadvantage of being highly volatile and as a result its activity is short lived. Also Dichlobenil is very expensive and if it could be used at lower rates the cost could be greatly reduced.

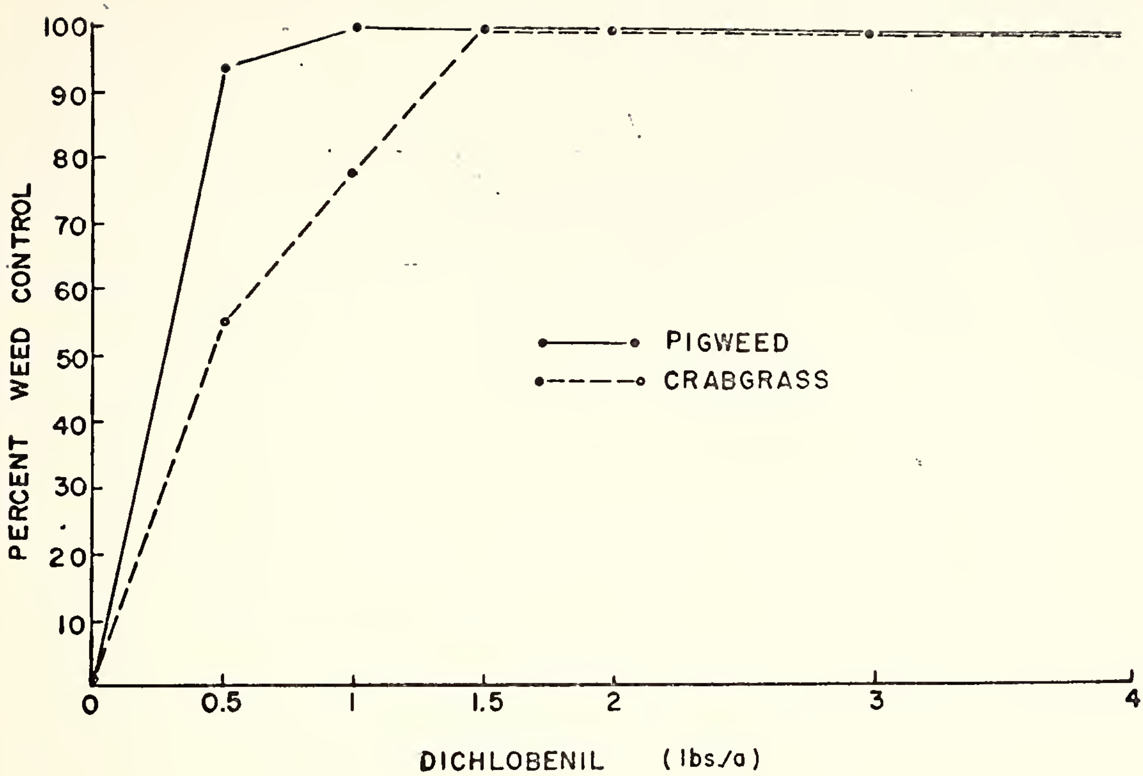

Fig. 1. The effects of dichlobenil at varying concentrations on the control of pigweed and crabgrass.

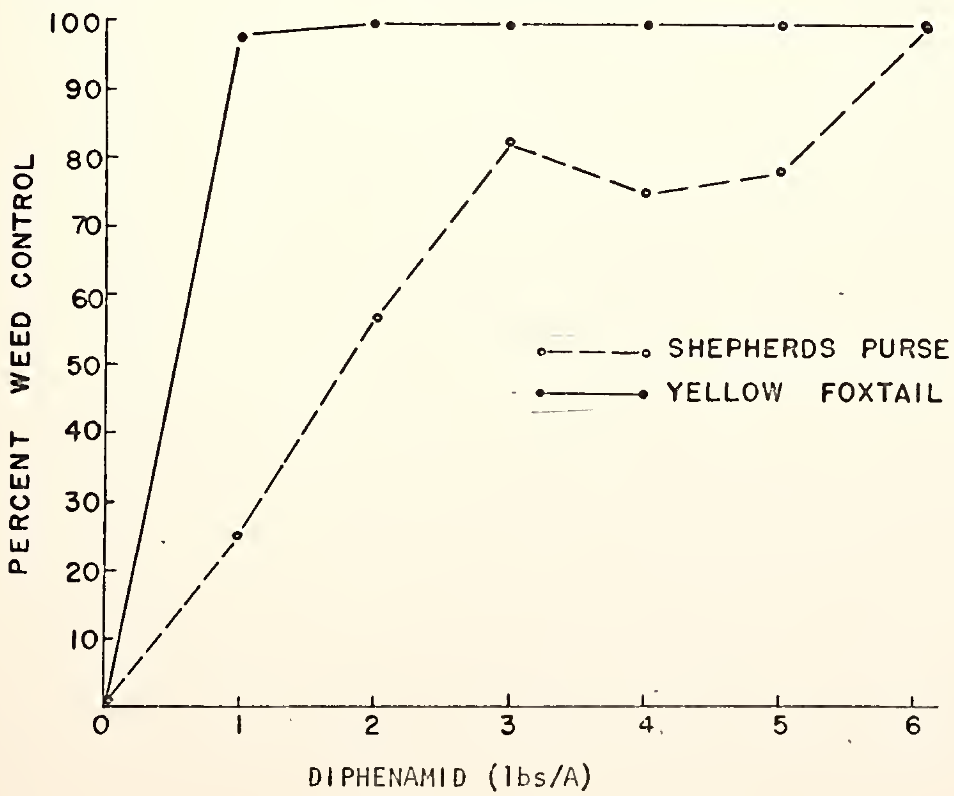

Fig. 2. The effects of diphenamid at varying concentrations on the control of shepherds purse and yellow foxtail.

Figure 2 represents the effect of diphenamid on Yellow Foxtail and Shepherd's purse. Notice that the diphenamid is more effective on the grass than on the broadleaf weeds. The results are very typical of the selectivity of diphenamid. However, the significant point to consider is the low concentration of diphenamid required to control the grass Yellow Foxtail. Diphenamid will remain active for 6-8 months which may be of advantage in a combination.

In Fig. 3 the control achieved by simazine from its normal rate of application (3 lbs./Acre) is compared to the minimum of 0.25 lbs/Acre. When the different herbicides were being studied for minimum concentrations, the question of a herbicide persistence became significant. In order to consider the length of time a herbicide might remain active in the soil a residual test was conducted. In Fig. 3 the minimum concentration of simazine required to control two weed species for a period of time is determined. Smartweed was controlled equally well at the same concentration both after one month and after four months. Simazine is known to be more selective toward broadleaf weeds and may explain the persistent effects. However, Yellow Foxtail was more tolerant and a higher concentration of 1 lbs/A was required to maintain complete control obtained 4 months earlier with .25 lbs/A.

Table 4 summarizes the results of the minimum concentrations required for selected species, which supports the conclusion that herbicide rates required vary with the weed species. Table 5 summarizes the data from the residual tests and illustrates the short residual activity of dichlobenil and the loss of effectiveness of certain herbicides on specific weeds while maintaining effectiveness on others.

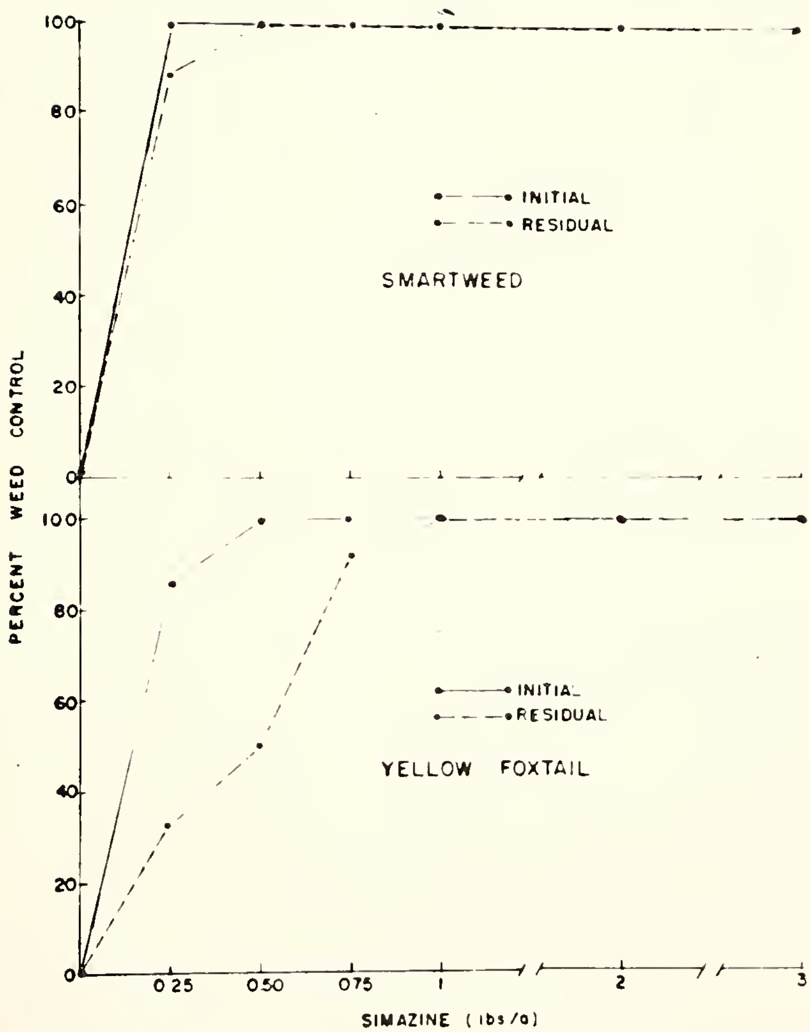

Fig. 3. The effects of simazine on initial and residual control of smartweed and yellow foxtail.

Having an idea of the minimum concentration required to control particular species and knowing that the low concentrations lose activity rapidly, it was then possible to formulate several combinations from these individual herbicides.

Field Results

As shown in Table 6, which compares the effectiveness of diphenamid and dichlobenil alone and in combinations, dichlobenil applied at the normal rate of 4 lbs/A controlled the broad spectrum of weeds. Diphenamid however, was only effective in controlling the grasses and a few broadleaf weeds as indicated by the limited control of weeds. In combination, the treatments were comparable to the dichlobenil applied alone. After a total period of two months the combinations were still as effective as dichlobenil at the higher concentrations, but less effective than after 1 month. By the end of three months there was very little difference among treatment means. When considering cost, the combination is less expensive than the dichlobenil applied alone, but the problem of limited residual activity due to the high volatility of the dichlobenil is very evident in these results as compared to the results obtained with the simazine-diphenamid combinations.

In comparing the simazine-diphenamid combination as shown in Table 7, the simazine at 3 lbs/A was the most effective of the three herbicides for the summer. However, at the 3 lbs/A rate, simazine is toxic to many ornamental plants. At the lower rates of simazine, weed control was good but not complete and did not persist as well. Diphenamid was very poor alone both at the 4 and 6 lbs/A rate. However, the combination simazine (1) + diphenamid (4) was quite effective during the first two months and allowed an average of only 2.9 weeds/sq. ft. during the third month. The lower concentrations of simazine applied singly was never as effective as this

Table 4. Summary of Minimum Concentration Required for Weed Control, as Indicated by Significant Differences at the 1% Level.

Weed Species	Simazine	Dichlobenil	Diphenamid
		lbs. per acre	
Chickweed	.25	.50	1
Shepherd's purse	.25	.50	3
Lambsquarter	.50	.50	NC**
Pigweed	.25	.50	1
Crabgrass	.25	.50	1
Barnyard grass	.25	.50	1

** NC indicates no significant weed control.

Table 5. Summary of Residual Tests for Minimum Concentration Required for Weed Control as Indicated by Significant Differences at the 1% level.

Weed Species	Simazine		Dichlobenil		Diphenamid	
	Initial	Residue	Initial	Residue	Initial	Residue
			lbs. per acre			
Yellow Foxtail	.25	.50	.50	NC**	1.0	1.0
Velvetleaf	.25	1.0	.50	NC	NC	NC
Smartweed	.25	.25	.50	1.5	NC	NC

** NC indicates no significant weed control.

Table 6. The effect of diphenamid and dichlobenil on weed control when applied alone and in combination. Treated June 6, 1966.

Herbicide (lbs/Acre)	Sampling date July 1	August 1	Sept. 1
	Average number of weeds per square foot		
Check	106	11	3.6
Diphenamid (6)	37	7	3.9
Diphenamid (4)	38	8	4.4
Dichlo. (1) + Diphen. (2)	1.2	4	1.4
Dichlo. (1) + Diphen. (4)	1	5	3.9
Dichlo. (2) + Diphen. (4)	1	3.6	2.8
Dichlo. (2) + Diphen. (2)	.2	3.6	2.4
Dichlobenil (4)	.3	3	2.9
Dichlobenil (2)	1.3	5	2.8

Table 7. The effect of diphenamid and simazine on weed control when applied alone and in combination. Treated June 6, 1966.

Herbicide (lbs/Acre)	Sampling date July 1	August 1	Sept. 1
	Average number of weeds per square foot		
Check	106	11	3.6
Diphenamid (6)	37	7	3.9
Diphenamid (4)	38	8	4.4
Sim. (.5) + Diphen. (2)	2.2	2	2.9
Sim. (1) + Diphen. (2)	2	1.6	2.5
Sim. (.5) + Diphen. (4)	1.6	4	1.3
Sim. (1) + Diphen. (4)	0	1	2.9
Simazine (3)	.4	1	.6
Simazine (1)	2.3	3.5	3.4

combination. Reduced injury or no injury to the crop may therefore be possible because of the reduced concentration. Also the possibility of soil residue build-up will be considerably reduced.

From the field experiment the herbicide combination simazine (1) and diphenamid (4) appears to be a possible combination that effectively controls weeds for a long period of time, while being less toxic to the crop. In addition, a broad spectrum of weeds is being controlled with less possibility of herbicide build-up in the soil.

Further research must now be performed to determine (1) the effect of time of application on these herbicide combinations; (2) if there are any toxic effects of the combinations on sensitive ornamental plants; (3) what formulation of the herbicide should be used; (4) the effects of various environmental factors on herbicide activity.

Summary

The principle of combining individual herbicide components with minimum concentrations into combinations that would control weeds as effectively as individual herbicides at higher concentrations was studied. From greenhouse and field plot studies the combination of simazine at 1 lb/A and diphenamid at 4 lbs/A was shown to give extended control over a broad spectrum of weeds. Because of the lower concentrations of the individual herbicide components, the possibility of reducing injury to sensitive crop plants is suggested. There are many implications of herbicide combinations in broad spectrum weed control that need to be investigated further.

INCORPORATION OF HERBICIDES IN MULCHES

Introduction

Organic mulches have frequently been used for weed control in woody ornamental planting beds but only with limited effectiveness. Generally the weed population is reduced but seldom is there complete weed control. In highway plantings it is becoming increasingly important to completely control weeds because of the rising labor costs. The greater effectiveness of certain herbicides in providing complete weed control is therefore of great interest. However, the problem in using herbicides on highway landscape planting beds is the difficulty of applying the herbicide accurately and uniformly to these irregular areas. Not only are the planting beds usually irregular in shape, but they are surrounded by turf which frequently is sensitive to some of these herbicides. Thus, if herbicides are to be used safely on planting beds, either extreme care is necessary or certain provisions must be made to increase the safety of their use.

We are interested in methods of application which will make herbicides safer for landscape usage. The approach that we have used is to incorporate the herbicides in organic mulches, such as peat-moss or shredded bark. By this incorporation we are diluting the herbicide to the point where it takes 2" or some other determined depth of the mulch to get the desired concentration of herbicide. Therefore, regardless of the shape of the area, the mulch, containing the proper proportion of herbicide, when applied at a given depth will accurately and uniformly distribute the herbicide. We were also interested to see if other values could be realized from this combination, since mulches by themselves aid in retention of soil moisture and moderate soil temperature, as well as aiding in the control of weeds.

Methods & Materials

In our initial study, we incorporated dichlobenil in peat-moss, using a 4% granular formulation, by thoroughly mixing it in a cement mixer. We used two concentrations and applied the mulch at two depths. The treatments were started in July of 1964 and weed counts were taken in August and October. Each plot was 6 sq. ft. in area and each treatment was replicated 4 times. The experiment utilized a split-plot design with the mulch depth as the main plot factor and the dichlobenil concentration as the sub-plot factor.

One of the secondary influences that was expected with the incorporation of herbicides in the mulch was weed control in subsequent years without further treatment. Therefore, the following summer we again conducted weed counts on these same plots which were left undisturbed.

In the spring of 1965, additional studies were initiated using other herbicides and mulches. The mulches used were peat-moss, crushed corncobs, and sawdust that was supplemented with nitrogen. The herbicides incorporated were dichlobenil at 4 lbs/A and a combination of simazine at 1 lb/A and diphenamid at 6 lbs/A. This combination was used as it has been found in other studies to provide effective broad spectrum weed control without the usual toxicity of simazine at higher rates. The mulch was applied at the 2" depth and 6 ornamental plants species were included to determine their response to the herbicide-mulch combination. The species included were *Euonymus fortunei* 'Coloratus'; *E. fortunei* 'Vegetus'; *Viburnum setigerum*; *Caryopteris incana*; *Forsythia intermedia*; *Acanthopanax sieboldianus*.

These plants were harvested in September and their fresh weight determined. The experiment utilized a split-plot design with mulches as the main plot and the herbicides as sub-plots. Each treatment was replicated

5 times and the plot size was 12 square feet. Only one plant per species was included in each experimental unit.

A comparison was made in 1966 between depth of mulch and the rate of herbicide applied to determine if the mulch decreased or increased the concentration of optimum effectiveness. A shredded bark mulch was used at 1, 2, and 4 inch depths with concentrations of dichlobenil varying from 2 to 8 lbs/A. The plots measured 2' x 4' and were replicated 12 times, using 12 different species of woody plants. Their growth was determined at the end of the first year by weighing the prunings from each plant.

Results and Discussion

In the initial study, the mulch by itself significantly reduced the weed population but did not completely control the weeds (Table 8). In fact the mulch increased the population of certain weeds while reducing the number of others. Complete weed control was only obtained with the use of dichlobenil alone or when incorporated into the mulch, indicating that the combination was at least as effective as the herbicide alone.

In the second year, weed control was far from complete. The 1- and particularly the 2-inch depth decreased the weed population as did the dichlobenil, particularly at the 8 lb/A rate, but the number of weeds existing the 2nd year even under the best treatment would be considered too high for a low cost maintenance program. The poor subsequent weed control was believed due to either the rapid decomposition rate of the peat moss which resulted in only a very thin layer of mulch remaining in the second year, or the fact that the peat moss served as a good weed seed germination media.

Table 8. The effects of dichlobenil and peat moss mulch, alone and in combination, on weed control.

Sampling date	Dichlobenil lbs/A	Depth of peat moss 0"	1"	2"
		Ave. no. of weeds per sq. ft.		
Aug. 11, 1964	0	13.6	2.5	2.5
	4	0	.1	0
	8	0	0	0
Oct. 10, 1964	0	1.0	.5	.5
	4	0	0	0
	8	0	0	0
June 3, 1965	0	90.8	69.8	42.5
	4	13.2	23.0	13.7
	8	3.9	6.5	2.7
July 9, 1965	0	103.3	59.8	24.5
	4	11.6	18.0	18.2
	8	9.8	5.1	2.9
Aug. 13, 1965	0	18.3	14.9	3.7
	4	3.6	4.6	6.2
	8	2.9	2.7	.4

In a subsequent experiment (Table 9), which was initiated late in the spring of 1965, the weed control was almost as effective initially with the mulch alone as in combination with the herbicides. This was also associated with a very low weed population due to the time of year the experiment was begun. However, it can be seen that mulch alone or with the simazine-diphenamid added did not have complete weed control whereas the mulches with dichlobenil did, as measured in July and August. It can also be seen that the dichlobenil alone became ineffective by August, but apparently remained effective when combined with the mulch. This becomes even more evident when weed counts are compared in the following year in this same experiment.

Even more significant is the difference in subsequent weed control in the different mulch treatments. Both the sawdust and corncobs treatments gave very effective weed control late into the second year, whereas the peat moss was far less effective and in certain cases had more weeds than the control. These results demonstrate the importance of the herbicide in the mulch for the initial control of weed seeds in the soil, but also the importance of using a mulch that will resist further weed seed encroachment and germination.

The effect of these treatments on plant growth was also considered. As shown in Table 10, the mulch and herbicide treatments had considerable effect on the growth of certain of the species. The growth of <u>Acanthopanax</u>, <u>Forsythia</u>, and <u>Caryopteris</u> was greater under the sawdust and peat moss, whereas the corn cobs decreased or did not greatly affect the growth. The reduced growth is probably due to a nitrogen deficiency brought about by the tie-up of nitrogen during the rapid decomposition of the corn cobs.

The dichlobenil treatment showed increased growth in <u>Acanthopanax</u> and <u>Forsythia</u> which can probably be attributed to the reduced competition from the weeds. In contrast, the dichlobenil treatment showed a decrease in growth

Table 9. The effects of herbicides and various mulches alone and in combination on weed control (treated June 6, 1965).

Sampling date	Herbicide treatment*	Mulch treatment			
		None	Sawdust	Corncobs	Peatmoss
		ave. no. of weeds per sq. ft.			
July 7, 1965	none	18.8	.5	.3	.5
	dichlobenil	1.2	.1	0	0
	sim. & dymid.	.3	.5	0	.5
Aug. 16, 1965	none	5.3	.2	.1	.5
	dichlobenil	4.0	0	0	0
	sim. & dymid.	.2	.1	0	.2
May 19, 1966	none	1.9	.3	.4	1.4
	dichlobenil	5.8	.4	.7	18.0
	sim. & dymid.	1.8	.4	.3	4.6
July 6, 1966	none	16.1	1.4	.3	6.7
	dichlobenil	52.2	.8	.7	7.4
	sim. & dymid.	14.2	.6	1.3	5.0

* dichlobenil = 4 lbs/A
Sim. & dymid = Simazine 1 lb/A and diphenamid 6 lbs/A

Table 10. The effects of herbicides and various mulches alone and in combination on the fresh weight of 6 woody ornamental plants.

Species	Herbicide treatment[1]	Mulch treatment[1] no mulch	sawdust	corncobs	peatmoss
		ave. fresh wt. per plant in gms.			
Acanthopanox sieboldianus	none	70	172	77	207
	dichlobenil	132	240	58	238
	sim. & diph.	4	169	48	263
Forsythia intermedia	none	195	304	171	474
	dichlobenil	355	386	202	455
	sim. & diph.	261	331	226	446
Caryopteris incana	none	347	555	461	479
	dichlobenil	285	89 (4)[2]	217 (1)	43 (4)
	sim. & diph.	410	563	497	558
Euonymus sarcoxie	none	19	11	11	7
	dichlobenil	37	33	8	12
	sim. & diph.	12	16	11	27
Euonymus fortunei 'Coloratus'	none	64	58	39	118
	dichlobenil	70	71	40	92
	sim. & diph.	42	72	33	87
Viburnum setigerum	none	32	28	26	37
	dichlobenil	25	33	17	26
	sim. & diph.	28	53	26	39

[1] dichlobenil applied at 4 lbs/A; sim. & diph. = simazine 1 lb/A and diphenamid 6 lbs/A

[2] ( ) indicates no. dead out of 5

with Caryopteris, which can be attributed primarily to the toxic effect of this herbicide on this species. In this species, toxicity is manifested by a brittleness which results in the breakage of plants in the wind. It can be noted that the greatest loss of plants was in the treatments where the herbicide is incorporated into the mulch. This is because the mulch actually enhances or protects the herbicidal activity of the dichlobenil by preventing its volatilization, usually a limiting factor of this herbicide.

There were very little difference between treatments on the Viburnum and Euonymus species, except for the increased growth of Euonymus fortunei 'Coloratus' with the peat moss.

Another factor that was considered was the depth of mulch, with and without herbicides, on weed control. In the spring of 1966, shredded bark mixed with composted sawdust applied at 1, 2, and 4 inch depths with 2, 4, and 8 lbs/A of dichlobenil resulted in the weed control shown in Table 11. Increasing the mulch to a 4 inch depth essentially controlled the weeds initially regardless of the addition of herbicide. The control, however, was not as complete later in the summer with just the mulch. The herbicide alone did not completely control the weeds either initially or later in the season but the combination of the herbicide dichlobenil at a 4 lbs/A rate incorporated into the shredded bark and used at a 1, 2, or 4 inch depth did give complete control. This provided additional evidence that the incorporation of the herbicide in the mulch not only gave equal weed control, but was better than either alone. This is explained by the protective cover the mulch provides the herbicide dichlobenil by preventing it's volatilization. This enhancement of the herbicide and resulting complete weed control, plus the ease of application, should make this a valuable technique for weed control in roadside plantings.

Table 11. The effects of mulch depth and herbicide concentration on weed control (treated April 1966).

Sampling date	Depth of mulch	Concentration of Dichlobenil (lbs/A)			
		0	2	4	8
		ave. no. of weeds per square foot			
July 11, 1966	0	77.7	---	3.4	---
	1	12.9	2.8	.7	---
	2	2.0	---	0	---
	4	.2	---	0	0
Sept. 13, 1966	0	8.7	---	4.7	---
	1	3.0	2.3	.6	---
	2	.2	---	.1	---
	4	1.4	---	0	0

The effect of these herbicide-mulch combinations on plant growth are shown in Table 12. Increasing the mulch depth in essentially every case increased the growth of the plants listed. This is not surprising since the mulch was acting as a fertilizer as well as aiding in moisture retention and moderating soil temperatures. The mulch contained 1/3 sawdust composted with nitrogen (N), phosphorus (P), and potassium (K), which is released slowly during the decomposition of the sawdust. This suggests another modification or application of the mulch combinations, which is to include a fertilizer as well as the herbicide. This technique is being considered further.

Other plants were included, but in general did not produce significant growth for measuring. These included Taxus media 'Hicks', Thuja occidentalis 'Techny', Pinus strobus, and Berberis thunbergi. One other species, Ligustrum vulgaris was the only species that was injured by the herbicide. In all treatment combinations including dichlobenil, the plants of this species were severely injured or killed.

Summary

The incorporation of dichlobenil into various mulches provided equal or more effective weed control than if either the dichlobenil or mulch was used alone. Certain mulches, such as composted sawdust and crushed corncobs provided better weed control the second year than peat moss. Increasing the depth of mulch up to 4 inches increased the weed control and with the mulch used, which contained sawdust composted with N, P, and K, the increased depth also increased the growth of many of the woody ornamental plants in the study as much as 300-400 percent. The main advantage of this technique is to facilitate the application of herbicides to irregular planting areas and to gain weed control in subsequent years from the mulch.

Table 12. The effect of mulch depth and herbicide concentration on the growth of several woody ornamental plants.

Species	Depth of mulch	Concentration of Dichlobenil (lbs/A) 0	2	4	8
		ave. fresh wt. in gms. per plant			
Spiraea	0	17.1	----	19.6	-----
vanhouttei	1	15.3	16.7	15.0	-----
	2	37.0	----	42.2	-----
	4	58.8	----	59.0	62.6
Cotoneaster	0	5.2	----	9.3	-----
acutifolia	1	2.8	8.0	11.6	-----
	2	6.2	----	18.8	-----
	4	16.6	----	25.5	13.0
Lonicera	0	13.7	----	25.6	-----
Zabeli	1	27.8	37.5	17.1	-----
	2	64.9	----	44.6	-----
	4	74.1	----	74.7	86.5
Weigela	0	26.1	----	48.6	-----
florida	1	57.1	64.6	67.1	-----
	2	83.6	----	147.8	-----
	4	150.6	----	112.6	111.7

THE USE OF ACTIVATED CARBON FOR LOCALIZED HERBICIDE PROTECTION

Introduction

The use of herbicides for weed control in any planting situation always involves the possibility of toxic effects to the cultivated crop. Generally herbicides are used which selectively kill the germinating weeds without causing injury to the crop. However, there is no single herbicide or herbicide combination that can be recommended for broad spectrum weed control that is also safe on all cultivated crops. Herbicide combinations look very promising as a means of overcoming this problem, but the research efforts so far have not completely alleviated this problem.

One approach that has been used to increase the tolerance of certain crops to triazine herbicides is to treat the roots of the plant with activated carbon. Thus, any herbicide that would come in contact with the roots and normally be absorbed by the roots will therefore be deactivated through adsorption to the activated carbon.

In this study the objectives were to 1) determine the applicability of this technique with ground covers that might be used on highway plantings in conjunction with herbicides, and 2) a deposit.

Methods and Materials

On May 17-18, 1965 a field experiment was initiated to evaluate the effectiveness of actuated carbon in providing localized protection for *Ajuga metallica* 'Crispa' to the herbicide simazine. Ajuga is extremely sensitive to simazine and therefore makes a good test plant.

Ajuga were planted 5 to a replication of which there were 4. The simazine was applied at 3 and 6 lbs/A or not at all. The activated carbon treatments, which were the sub-plots in a split plot design, were 1) no carbon, 2) a surface treatment to the peat pot in which the plants were growing, and 3) depositing 100 cc of the carbon in the planting hole. The plants were treated with activated carbon and after the planting operation was complete, the simazine was applied.

A similar experiment was initiated in July of the same year, again using Ajuga. The rates were 1, 2, and 4 lbs/A of simazine and these plants were observed in October for survival.

The inconsistent results obtained between the May and July experiments suggested environmental differences may be important in the effectiveness of the carbon treatment. To investigate this possibility, similar treatments were set up in the greenhouse where the soil temperature was controlled at 60, 70, or 80^{o}F. This was started February 7, 1966 and completed March 28, 1966. The treatments included 1) a surface treatment of the peat pot with activated carbon, 2) a deposite of 100 cc of activated carbon around the root mass, 3) incorporation of carbon into the entire soil mass at a ratio of 1 part carbon to 8 parts soil, 4) no carbon, 5) no carbon and no simazine. All of the treatments except the last were treated with 2 lbs/A of simazine.

A final experiment was initiated on July 22, 1966 which compared two methods of protection; 1) surface treatment of the peat pot, and 2) incorporation of activated carbon in a 6 inch circle around the plant at a ratio of 1 part carbon to 6 parts soil. Simazine was applied at 1 and 3 lbs/A. The measurements on these Ajuga plants were taken September 23, 1966. The experiment consisted of 4 replications with 4 plants in each.

Results and Discussion

The effectiveness of activated carbon in providing localized protection to Ajuga plants from possible simazine injury is shown in Table 13. It was apparent that there was definite protection, although certainly not complete. Less than 50% survival is certainly not sufficient protection for any planting operation. The levels of simazine used in this experiment are the recommended rates but if the practice of combining simazine with diphenamid is adopted, then only 1 lb/A would be used. Protection at this level is shown later.

When this experiment was repeated in July of the same year using 1, 2, and 4 lbs/A the only plants that survived were the controls and a few treated with only 1 lb/A of simazine that had some carbon protection. These results were not consistent with the results obtained in the spring treated plants that had some survival even at the 6 lbs/A rate of simazine. This suggested that the time of year might be important in the effectiveness of this technique. One difference that appeared important was a 10^{o}F increase in soil temperature from May to July.

To determine the importance of soil temperature, controlled root zone chambers were utilized and the temperatures were maintained at 60, 70, and 80^{o}F. The results of this study are shown in Table 14.

It was quite apparent that soil temperature influenced the effectiveness of the activated carbon. At the lower temperatures, all methods of activated carbon protection were equally effective. At the higher temperatures the most effective treatment was with the carbon incorporated into the entire soil mass, followed by the addition of 100 cc of the carbon to the area surrounding the root mass. It appears that the high soil temperature accentuates root

Table 13. The effect of activated carbon for localized protection of *Ajuga metallica* 'Crispa' from simazine toxicity.

Activated Carbon Treatment	Simazine (lbs/A) 0		3		6	
	% dead	Ave. diameter inches	% dead	Ave. diameter inches	% dead	Ave. diameter inches
check	5	25.2	100	11.3	100	0
surface	0	26.5	55	14.2	70	5.2
100 cc	10	25.4	40	25.5	60	8.9

Table 14. The influence of soil temperature on the relative effectiveness of various methods of activated carbon protection on *Ajuga* from an application of 2 lbs/A of simazine.

Activated Carbon & Simazine Treatment	Soil Temperature °F 60	70	80
	ave. plant diameter in inches		
check (no simazine)	5.2	6.5	6.5
no carbon	.3	0	0
surface of peat pot	5.5	3.0	.3
100 cc around pot	5.8	4.5	3.5
incorporated 1:8	5.0	5.0	5.0

growth and thus the roots grow out of the protection zone. That is why the incorporation treatment is most effective since the roots are always in the protection zone. In contrast, the surface and 100 cc treatments only provide protection until the roots grow beyond the carbon.

In the field study initiated in July of 1966, this incorporation technique was used, and as shown in Table 15, this gave excellent protection if only 1 lb/A of simazine was applied. At the higher rate of 3 lbs/A this protection was not quite adequate. However, as shown in the herbicide combination study, only 1 lb/A of simazine is needed when combined with diphenamid and this technique would therefore provide sufficient protection.

Summary

The use of activated carbon for localized protection of plants sensitive to certain herbicides such as simazine appears to be promising, limited to the extent of protection it can provide. The time of application and method are quite important in determining its effectiveness.